EXPRESS MAIL" MAILING LABEL

NUMBER: ER 387203206US

DATE OF DEPOSIT: December 17th 2003

I hereby certify that this paper or fee is being deposited with the United States Postal Service "EXPRESS MAIL POST OFFICE TO ADDRESSEE" service under 37 C.F.R. 1.10 on the date indicated above and is addressed to:

Mail Stop Patent Application, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Signature

APPLICATION FOR PATENT
FOR
DOWNHOLE ROTATING TOOL

Inventor: Charles H. Bishop

ASSIGNEE: BAKER HUGHES, INCORPORATED

PATENT
584-29861US (102.69)

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates generally to the field of exploration and production of hydrocarbons from wellbores. More specifically, the present invention relates to a method and apparatus to provide for controlled rotation of a downhole tool. Yet even more specifically, the present invention relates to a method and apparatus to control the rotation of a downhole tool within a wellbore in order to orient the downhole tool in a designated azimuthal direction.

2. Description of Related Art

Of the many tools used in conjunction with downhole wellbore operations, the function of some of these tools can be optimized by orienting the specific tool in a certain radial position about the tool's axis. Often times however the tools are suspended within the wellbore only by a wireline, which makes it virtually impossible in vertical sections of the wellbore to place the downhole tool in a specific orientation.

Others have attempted to solve the problem of orienting downhole tools within a wellbore that are inserted into the wellbore by wireline. These attempts include integrating motors with the downhole tool that are designed to rotate the tool into a desired orientation. Other attempts involve setting an anchor within the wellbore, measuring the azimuth of a reference within the anchor, and then adjusting a downhole tool such that when it is mated with the anchor, the downhole tool is oriented in the desired azimuthal setting. Yet other attempts include utilizing an indexing tool comprising a mandrel with "J" slots formed on its outer radius and a corresponding outer sleeve with set pins that travel within the "J" slots. Repeated upward and downward movement of the mandrel with respect to the sleeve produces radial rotation of the tool. Examples of these devices and other apparatus and

methods for azimuthally orienting downhole tools can be found in U.S. Patent No. 5,010,965, U.S. Patent Application No. 2003/0111235 A1, U.S. Patent No. 6,223,824, U.S. Patent No. 5,360,066, and U.S. Patent No. 6,003,599.

Various shortcomings however are present in each of these aforementioned devices for evaluating and affecting the azimuthally orientation of downhole tools. For example, many wellbores, especially hydrocarbon producing wellbores, experience high pressures at depths within the wellbore. It is doubtful that the tools utilizing motors would rotate at the desired rate and distance because of the effect the high pressure pushing inward on the seals on the rotating members of the tool. As far as azimuthally orienting a tool with an anchor and corresponding reference marks, this requires the additional costly and time consuming steps of retrieving a portion of the tool from the wellbore, adjusting the corresponding marks on the downhole tool, and then inserting the tool into the wellbore. Further, with respect to implementing indexing tools to affect radial rotation, the slots in the tool can become clogged with wellbore debris such as proppant, sand, and other solids.

Therefore, there exists a need for azimuthally orienting devices within wellbores that can allow the tools to be rotated at any pressure within the wellbore, requires a minimum number of steps, and will not be affected by solid particulate within wellbore fluid.

BRIEF SUMMARY OF THE INVENTION

The present invention includes a rotating tool comprising a body, a compression assembly, a hydraulic assembly, and a lead screw. The compression assembly comprises a selectively compressible compression element and the hydraulic assembly comprises a reservoir having an open end and a closed end. The reservoir is fillable with fluid and formed to receive a piston within its open end. The piston is threadingly coupled with the lead screw and slidingly coupled with the body such that movement of the piston towards the closed end causes rotation of the piston that correspondingly produces rotation of the body. Potential

energy is capable of being stored within the compression element. Alternatively, the fluid is disposed within the reservoir between the piston and the closed end. The hydraulic assembly can be coaxial with the compression assembly and is capable of selectively providing a reactive force to maintain the compression element in a compressed state. The fluid from the reservoir removes the reactive force and enables movement of the piston towards the closed end.

The compressive assembly further comprises a rotor provided on the end of the compressive element distal from the hydraulic assembly, and a thrust cup provided on the end of the compressive element proximate to the hydraulic assembly. The rotating tool of the present invention further comprises a collar coaxially connecting the hydraulic assembly to the compressive assembly. The compressive element can include a helical spring, at least one Bellville washer, a gas filled cylinder, and a coiled spring.

The rotating tool of the present invention can further comprise an orifice formed on the hydraulic assembly providing fluid communication between the reservoir and the outside of the hydraulic assembly. Further included is a valve included with the orifice, the capable of valve selectively providing fluid flow through the orifice. Optionally included is an anchoring device capable of anchoring the rotating tool within a wellbore and stabilizing the lead screw during rotation of the body. The reservoir is preferably comprised of an elongated annulus and the piston comprises an elongated tube formed for insertion into the elongated annulus. The body comprises a sleeve that encompasses a portion of the rotating tool. The present invention can further comprise a gyroscope operatively connected to the rotating tool. A downhole tool can be operatively connected to the rotating tool of the present invention such that rotation of the rotating tool causes rotation of the downhole tool.

The present invention includes a method of using the rotating tool, the method comprises, compressing the compression element, sealing the fluid within the reservoir thereby providing a reactive force to maintain the compression element in a compressed state, and removing the reactive force from the compression element thereby allowing the piston to be urged along the length of the lead screw towards the closed end of the reservoir by the decompression of the compression element. Whereby the threaded coupling of the piston with the lead screw produces rotation of the piston that in turn produces rotation of the body.

With regard to the method of the present invention, the step of removing the reactive force from the compression element is accomplished by metering the fluid out of the reservoir. The method of the present invention can further comprise disposing the rotating tool within a wellbore as well as anchoring the lead screw within the wellbore. The method can further include adding a gyroscope to the rotating tool and calibrating the rotating tool. Optionally a downhole tool can be attached to the rotating tool of the present invention and azimuthally orienting the downhole tool by to a desired position by rotating the rotating tool a certain amount.

Accordingly, one of the advantages provided by the present invention is the ability to orient a downhole tool deep within a wellbore, even when the downhole tool is suspended on a wireline.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING.

Figure 1 depicts a cross section of a wellbore with one embodiment of the present invention in use with a perforating gun.

Figure 2 illustrates a partial cross sectional view of one embodiment of the present invention.

Figure 3 depicts a side view of one embodiment of the present invention.

Figures 4a and 4b depict a cross sectional view of an embodiment of the present invention.

Figure 5 illustrates an embodiment of a solenoid assembly for use with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

With reference to the drawing herein, one embodiment of a rotating tool 10 is illustrated in Figure 1. There the rotating tool 10 is shown within a wellbore 5 as part of a tool string 3 further including a gyroscope 56 and a perforating gun 80. The combination of rotating tool 10 and perforating gun 80 is suspended within the wellbore 5 by a wireline 7. As is well known, the wireline 7 can be suspended from a spool (not shown) and threaded through a series of pulleys 8 to guide it into the wellbore 5. Preferably the wireline 7 is the well known variety capable of conveying data along its length from the earth's surface to and from the rotating tool 10, however the wireline 7 can also comprise slickline, coiled tubing, and any other line capable of tethering a downhole tool within a wellbore 5. It should also be pointed out that downhole tools other than the perforating gun 80 can be combined with the rotating tool 10, such as logging devices and downhole production devices, among others.

An anchor 60 is also shown in Figure 1 preferably secured to a shaft 62 extending from the upper portion of the rotating tool 10. The anchor 60 should provide sufficient radial resistance to rotation such that when the rotating tool 10 rotates (as will be explained in more detail below), the anchor 60 remains in place thereby preventing any corresponding twisting or rotation of the wireline 7. However the anchor 60 should not impart such a force onto the wellbore 5 such that the vertical travel of the rotating tool 10 within the wellbore 5 is not impeded. While the anchor 60 as illustrated in Figure 1 is a well known centralizer type anchoring device, any other anchoring device can be implemented, such as outwardly extending slips, nipple profiles within the wellbore, and any other now known or later

developed device capable of suitably anchoring the rotating tool 10 at a certain location within the wellbore 5.

With reference now to Figure 2, there is illustrated a partial cross sectional view of one embodiment of the rotating tool 10 within a wellbore 5. The rotating tool 10 of Figure 2 is comprised primarily of a compression assembly 22, a hydraulic assembly 30, and a stationary assembly 50. The compression assembly 22 of this embodiment comprises a rotor 12, a spring 14 adjacent to the rotor 12, and a collar 24. The rotor 12 is preferably cylindrical with a substantially planer surface on the end of the rotor 12 distal from the spring 14.

The end of the rotor 12 generally projecting downward comprises a recessed ledge 15 having a smaller diameter than the diameter of the remaining portion of the rotor 12. At least one bolt hole 23 is formed on the surface of the recessed ledge 15 to provide a manner of attaching a sleeve 26 to the rotor 12. Preferably the at least one bolt hole 23 is threadingly formed to receive a bolt 25 or other threaded fastener thereby enabling relatively quick and easy attachment and detachment of the sleeve 26 to the rotor 12. While the preferred manner of securing the sleeve 26 to the rotor 12 includes corresponding bolts 25 and bolt holes 23, any other now know or later developed manner of mechanical attachment can be employed, such as rivets, threading the recessed ledge 15 and inner diameter of the sleeve, and pins among others.

The terminal end of the rotor 12 proximate to the recessed ledge 15 can optionally be recessed inward along its diameter to provide a mating surface where the rotor 12 contacts the spring 14. During operation of the rotating tool 12 the rotor 12 will be pushing against the spring 14 in order to compress it.

An additional embodiment of the rotating tool 10 is shown in a cross-sectional view in Figures 4a and 4b where additional detail of the rotor 12 and the lead screw 16 with the attached screw extension 74 is illustrated. The screw extension 74 is preferably an elongated

member having a largely cylindrical cross section along its axis. A generally cup like socket 75 is disposed on the upper end of the screw extension 74 that is coaxial with the screw extension 74. The socket 75 is upwardly facing with a cylindrically shaped hollowed out section, where the hollowed out section is mostly coaxial with the screw extension 74. The socket 75 can be integrally formed with the screw extension 74, or the socket 75 and screw extension 74 can be separately formed and joined by welds, threads, bolting, or any other known or later developed type of connection.

A cocking bit 76 is situated within the hollowed out section of the socket 75. Preferably the cocking bit 76 is threadingly connected within the socket 75 as shown, but can also be welded, bolted, connected with pins, or any other known or later developed connection method. A compression nut 21 is included on the cocking bit 76 adjacent to the upper end of the rotor 12. The compression nut 21 is preferably integral with the cocking bit 76, where the cocking bit 76 is rotatable with respect to the rotor 12. Accordingly rotation of the compression nut 21 is capable of producing corresponding rotation of the lead screw 16 without causing subsequent rotation of the rotor 12.

Extending upward from the compression nut 21 is the upper tip 79 of the cocking bit 76 that terminates with a threaded fitting 19. The upper tip 79 is generally cylindrical with an inner passage formed along its axis. Contained within the inner passage are a spring 65 and an electrical connector 64. The spring 65 is capable of providing an outward pushing force against the electrical connector 64. An electrical connection between the electrical connector 64 and a terminal (not shown) can be maintained by the pushing force of the spring 65 on the electrical connector 64. Preferably a passage 13 is formed substantially along the entire length of the rotating tool 10. The passage 13 can be used to contain a data transmitting wire and therefore should be of sufficient diameter to accommodate such a wire. The wire should be electrically connected with the electrical connector 64 thereby enabling electrical

communication between the internal components of the rotating tool 10 and the surface of the wellbore 5. Preferably the data transmitting wire is comprised of a coil spring wire that is capable of being rotated and twisted without being damaged.

Threads (not shown) corresponding to the threaded fitting 19 are formed within a hollowed portion of the shaft 62 that enable a means to connect the shaft 62 to the cocking bit 76. Since the shaft 62 is secured to the wireline 5 via a cablehead 63, affixing the cocking bit 76 to the shaft 62 serves to suspend the cocking bit 76 (and thus the remainder of the rotating tool 10) within the wellbore 5. Further, joining the cocking bit 76 to the shaft 62 effectively joins the lead screw 16 to the shaft 63. This sequence of connections prevents rotation of the lead screw 16 when the rotating tool 10 is situated within the wellbore since the lead screw 16 is effectively attached to the anchor 60.

The inner bore of the rotor 12 and the outer diameter of the screw extension 74, socket 75, and cocking bit 79, the rotor 12 must be able to rotate freely around these elements. To facilitate free rotation of the rotor 12 around the screw extension 74, socket 75, and cocking bit 79 bearings (77 and 78) are situated at certain locations along the inner circumference of the rotor 12. More specifically, rotor bearings 77 included between the inner bore of the rotor 12 and the screw extension 74, these bearings 77 are proximate the lower end of the rotor 12 and also proximate to the lower end of the socket 75. Roller bearings 77 are also disposed between the inner bore of the rotor 12 and the cocking bit 76 proximate to the upper most end of the rotor 12. Thrust bearings are located between the lower base of the socket 75 and a ledge 82 formed within the inner bore of the rotor 12. The ledge 82 is included to supply an upward force against the base of the socket 75.

The rotor 12 is shown in Figure 4a and 4b as being bored along its axis, where the bore is formed to circumferentially encompass the socket 75, the lower portion of the cocking bit 76, and a portion of the screw extension 74. The portion of the screw extension 74 not

circumscribed by the rotor 12 extends downward towards the lead screw 16 and is coaxially disposed within the spring 14. Attachment of the lead screw 14 to the screw extension 74 preferably comprises a threaded connection, but can be of any other type of connection capable of securing these parts in a coaxial arrangement.

A collar 24 is positioned on the end of the spring 14 opposite to where it contacts the rotor 12. On its upper end, the collar 24 includes a thrust cup 20 that is an upwardly facing hollowed out cylinder formed to receive the lower end of the spring 14.

Also similar to the rotor 12, an aperture is fashioned through the collar 24 along its axis formed to receive the lead screw 16. The portion of the lead screw 16 positioned within the aperture of the collar 24 contains threads 17 on its outer surface. The lead screw 16 is designed to rotate within the aperture of the collar 24; bearings 27 are preferably included within this aperture to alleviate any resulting frictional forces between the lead screw 16 and the collar 24. More preferably the bearings 27 are part of a re-circulating bearing mechanism. With reference now to Figure 2 more detail is provided for this embodiment of the invention; inside the collar 24 are numerous ball bearings 27 adjacent one another within the tube 25 along the length of the collar 24. The ball bearings 27 become disposed within the trough along the threads 17. As the lead screw 16 turns, the ball bearings 27 travel down the threads 17 along the length of the collar 24. As each ball bearing 27 reaches the end of the collar 14, it is forced up and over the top of the collar 24 through a tube 25 attached to the outer surface of the collar 24. The other end of the tube 25 is attached at the upper end of the collar 24, where the bearing 27 can be deposited back into the bearing trough for another trip through the collar 24. Hence the term, "recirculation lead screw collar."

As previously noted, one embodiment of the hydraulic assembly 30 is located adjacent the compression assembly 22 and comprises a piston 32 combined with a hydraulic reservoir body 40. The piston 32 includes a piston body 34 that is substantially tubular being open on

one end and closed on the other by the presence of the piston head 34. The piston head 34 is preferably disk like in shape and aligned coaxial with the piston 32. Keys 35 are provided on the outer radius of the piston head 34 and formed to mate with a vertical slot (not shown) disposed on the inner radius of the sleeve 26. The presence of the keys 35 combined with the vertical slot allow the piston head 34 (and thus the piston 32) to travel axially within the sleeve 26, but prevent rotation of the piston 32 with respect to the sleeve 26. A threaded aperture 36 is formed axially through the piston head 34 whose threads are shaped to mate with the threads formed on the lead screw 16.

The hydraulic reservoir body 40 comprises primarily a pair of sleeve like tubulars (inner tube 45 and outer tube 43) connected on their ends to the reservoir base 47. The inner tube 45 should be disposed coaxial within the outer tube 43 thereby forming an annulus 49 between these two tubes. To ensure that the width of the annulus 49 is substantially constant along its radius, the axes of the inner tube 45 and of the outer tube 43 should be closely aligned. The dimensions of the annulus 49 should match the dimensions of the piston body 38, such that the open end of the piston body 38 can be easily urged in and out of the annulus 49. Preferably at least one O-ring 53 is included on the outer wall of the piston body 38 and at least one other O-ring 53 is also included on the inner wall of the piston body 38. These O-rings 53 provide a sealing contact between the piston body 38 and the annulus 49.

A hydraulic reservoir 42 is situated within the reservoir base 47. While the hydraulic reservoir should 42 should be capable of storing fluid within without leakage, it is in fluid communication with the annulus 49 via at least one opening 55 through the housing of the hydraulic reservoir 42. Attached to the reservoir base 47 opposite to the inner and outer tubes (43 and 45) is a valve assembly 59 having a solenoid valve 85 and a reservoir orifice 44. Actuation of the solenoid valve 85 is accomplished by the attached solenoid 46. The hydraulic reservoir 42 can be in fluid communication with the valve assembly 59 through a

port 57 located on the wall of the reservoir base 47 where it is attached to the valve assembly 59. An inlet channel 84 and an outlet channel 88 within the valve assembly 59, in combination with the reservoir orifice 44 and the solenoid valve 85, provides selective fluid communication between the outside of the valve assembly 59 to the hydraulic reservoir 42. Selective fluid communication through the valve assembly 59 is accomplished by positioning the solenoid valve 85 so that the elastic rings 86 disposed on the outer circumference of the solenoid valve 85 coincide at the points where the inlet and outlet channels (84 and 88) enter the solenoid chamber 89.

In more detail, the solenoid chamber 89 within the valve assembly 59 should be formed for insertion of the solenoid valve 85 and also provide a fluid flow path over the solenoid valve 85 when it is in the open position and the elastic seals 86 are not plugging the inner or outlet channels (84 and 88). As can be readily understood by those skilled in the art, translational actuation of the solenoid valve 85 in and out of the solenoid channel 89 can in turn provide for fluid flow, or block fluid flow, through the valve assembly 59. Although not shown in Figure 5, the outlet channel 88 is in fluid communication with the reservoir orifice 44. Similarly, the inlet channel 84 is in fluid communication with the hydraulic reservoir 42.

The embodiment of the rotating tool 10 of Figure 2 terminates with a stationary assembly 50. The stationary assembly 50 comprises a pressure equalizing system and a connection point between the rotating tool 10 and remaining components of the tool string 3. A pair of cascading surfaces (66 and 68) provides connection points for connecting the stationary assembly 50 to the rotating tool 10 and for securing one end of the sleeve 26. The first cascading surface 66 should extend away from the stationary assembly 50 up towards the hydraulic assembly 30. Like the recessed ledge 15 of the rotor 12, the outer radius of the first cascading surface 66 should be recessed inward from the outer circumference of the rest of the stationary assembly 50 so that the inner circumference of the sleeve 26 can snugly fit over

the outer surface of the first cascading surface 66. Further, also similar to the recessed ledge 15, the first cascading surface 66 should include at least one bolt hole 23 so that a fastener (not shown) can be used to secure the sleeve 26 to the stationary assembly 50. Like the first cascading surface 66, the second cascading surface 68 should extend away from the stationary assembly 50 up towards the hydraulic assembly 30. Preferably at least two connector rods 48 are connected to the second cascading surface 68 and the outer radius of the hydraulic reservoir 42. To accommodate the presence of the connector rods 48, the radius of the second cascading surface 68 should be sized to prevent the connector rods 48 from interfering with placement of the sleeve 26 onto the rotating tool 10.

Optionally, stator pistons 54 can be included with the stator 51 inside of stator pressure ports 52. Preferably the stator pistons 54 are disk like in shape and have a circular outer surface. Consequently the pressure ports 52 should be formed with corresponding circular walls to allow free travel of the stator pistons 54 along the respective lengths of the pressure ports 52. The pressure ports 52 should be formed within the stator 51 and along its axis.

The stationary assembly 50 can provide a means for attaching remaining elements of a tool string 3 within a wellbore 5. In the embodiment of Figure 2 a connector 58 is illustrated that connects a gyroscope 56 to the rotating tool 10. It is important that the connector 58 that secures the rotating tool 10 to the gyroscope 56 or other devices are rigid and not susceptible to any twisting, elongation, or contraction that might skew the gyroscope readings. Examples of suitable connectors 58 are any type of threaded connection, such as a threaded pipe, that is capable of providing a relatively stiff and unyielding connection between the gyroscope 56 and the rotating tool 10.

As far as the materials of the rotating tool 10, most of the components can be made of 4140 carbon steel, or any number of other suitable alloys. However, due to the forces

involved and the harsh downhole environment, it is preferred that the lead screw 16 be made from 5160 carbon steel, the spring 14 be made with chrome vanadium, and that the bearings, and associated races be made from Timken 52100. Timken 52100 is available from The Timken Company, 1835 Dueber Ave. SW, P.O. Box 6932, Canton, OH.

In operation, before the rotating tool 10 is connected (or made up) to the tool string 3, the compression assembly 22 is put into the cocked position. Cocking the compression assembly 22 involves urging the collar 24 upward towards the rotor 12 thereby contracting the spring 14 into a compressed position. This is accomplished by rotating the lead screw 16 that in turn draws the piston 32 upward towards the rotor 12 as the piston 32 rides on the threads of the lead screw 16. The rotational movement of the lead screw 16 is converted into translational movement due to the interaction of the corresponding threads located on the lead screw 16 and the piston head 34. Since the piston head 32 and the thrust cup 20 are attached on opposite ends of the collar 24, upward movement of the piston head 32 produces upward movement of the thrust cup 20. Thus urging the piston head 32 upward by rotating the lead screw 16 necessarily results in compression of the spring 14. The compression nut 21 that is provided on the shaft of the lead screw 16 can be rotated with a wrench or other tool to manually rotate the lead screw 16.

The amount of compression applied to the spring 16 will depend on the particular spring employed and the application of the rotating tool 10, however it is believed that the amount of compression can be determined by those skilled in the art without undue experimentation. When the cocking procedure has been completed and the spring 14 has been compressed to the desired amount, a signal is sent to the solenoid 46 that closes the solenoid valve within the valve assembly 59. Once the solenoid valve is closed the fluid is sealed within the hydraulic assembly 30. After the solenoid valve is fully closed, the cocking force applied to compress the spring 14 can be released. As long as the fluid is sealed within

the hydraulic assembly 30 by the closed solenoid valve, the piston 32 is prevented from moving downward within the annulus 49. Thus closing the solenoid valve also operates to maintain the spring 14 in the compressed state thereby storing potential mechanical energy within the spring 14.

To prevent producing a vacuum within the hydraulic assembly 30 during the cocking procedure, the solenoid valve should be put into the open position to allow fluid communication between the outside of the valve assembly 59 and the hydraulic reservoir 42. This should be done prior to actuating the lead screw 16. Fluid, preferably hydraulic fluid, is supplied to the reservoir orifice 44 as the piston 32 is drawn upward by the rotation of the lead screw 16. The fluid supplied to the reservoir orifice 44 migrates through the valve assembly 59 and into the hydraulic reservoir 42 during the cocking procedure. From the hydraulic reservoir 42 the fluid can flow through the openings 55 in the reservoir base 47 into the annulus 49. As previously noted, actuation of the solenoid valve is accomplished by energizing the solenoid 46, preferably by the well known method of supplying an electrical current to the solenoid 46 through conducting wire 71 from an electrical current source (not shown). However, the manner of supplying current to the solenoid 46 can be any known or later developed method.

After the rotating tool 10 is cocked, it can be combined with other devices in a tool string 3. In the embodiment of rotating tool 10 displayed in Figure 1, the rotating tool 10 can be combined with a gyroscope 56 and a perforating gun 80. It is important though that the connectors 58 used to couple the tool string 3 be rigid and not susceptible to any twisting or elongation. Once the tool string 3 is assembled it can be deployed into the wellbore 5 to the depth where it is to be used.

While the anchor 62 generally inhibits rotation of the tool string 3 within the wellbore 3, the tool string 3 will experience some rotation during its descent into the wellbore 3. As

stated above, the effectiveness of some downhole tools is dependent upon their azimuthal orientation; which is especially true with perforating guns 80. Rarely will the tool string 3 be in the desired azimuthal orientation when lowered to the depth for use of the particular downhole tool, thus the tool string 3 will typically require some rotating in order to position it in the desired orientation. Before the tool string 3 is rotated, the attached gyroscope 56 measures the actual azimuthal orientation of the tool string 3. The orientation measurement is then transmitted via the wireline 7 to the surface. Surface personnel can then compare the actual orientation versus the desired orientation and determine the angular variance between the two orientations.

Rotation of the rotating tool 10 can be initiated by energizing the solenoid 46 thereby opening the solenoid valve. When the solenoid valve is put into the open position, the fluid within the hydraulic assembly 30 can flow out of the annulus 49 and the hydraulic reservoir 42 through the reservoir orifice 44 into the space outside of the valve assembly 59 and within the sleeve 26. Allowing the fluid to exit the hydraulic assembly 30, combined with the mechanical energy stored in the spring 14, produces movement of the piston 32 downward into the annulus 49 towards the reservoir base 47. As the piston 32 moves downward the interaction of the threads 17 on the lead screw 16 with the threaded aperture 36 on the piston head 34 produces a rotation of the piston 32 with respect to the lead screw 16. Since the lead screw 16 is held stationary by virtue of its connection to the anchor 62, the piston 32 rotates as it moves along the threaded portion of the lead screw 16. Further, as the piston 32 moves downward within the sleeve 26, the keys 35 that jut radially outward from the piston head 34 impart a corresponding rotational force on the sleeve 26 while sliding downward within the vertical slot. The rotational force applied to the sleeve 26 by the piston head 34 and keys 35 is sufficient to rotate the sleeve 26. Since the sleeve 26 is a mechanically fastened integral

part of the rotating tool 10, rotation of the sleeve 26 in turn causes rotation of the rotating tool 10.

While the solenoid valve is opened, a series of data pulses are transmitted to surface personnel that are operating the rotating tool 10. Calibration of the rotating tool 10 can be accomplished in any one of a number of ways, such as by positioning the gyroscope 56 to point to a true north, rotating the rotating tool 10 until the gyroscope 56 is pointing to another known direction, such as east, and counting the number of data pulses received. Azimuthal orientation can be determined by the data being transmitted back to the surface or acquisition system and interpreted by a person skilled in the art. As soon as it is determined that the rotating tool 10 has rotated into the desired orientation, another command can be issued by the operational personnel to close the solenoid valve, thereby ceasing rotation. The orientation can be verified by taking another reading with the gyroscope 56 thereby ensuring that the downhole tool is oriented in the proper azimuthal angle. If the proper angle has been achieved, the downhole tool can be actuated, if not, the orientation process can be repeated.

The present invention described herein, therefore, is well adapted to carry out the objects and attain the ends and advantages mentioned, as well as others inherent therein. While a presently preferred embodiment of the invention has been given for purposes of disclosure, numerous changes exist in the details of procedures for accomplishing the desired results. For example, the spring 14 can be replaced with some other device capable of imparting a pushing force against the piston. Examples include Bellville washers, a pressurized cylinder filled with gas or fluid, and a coiled spring. These and other similar modifications will readily suggest themselves to those skilled in the art, and are intended to be encompassed within the spirit of the present invention disclosed herein and the scope of the appended claims.